Infrared Spectroscopy of High-Tc Superconductors

D.N. Basov, *UCSD*

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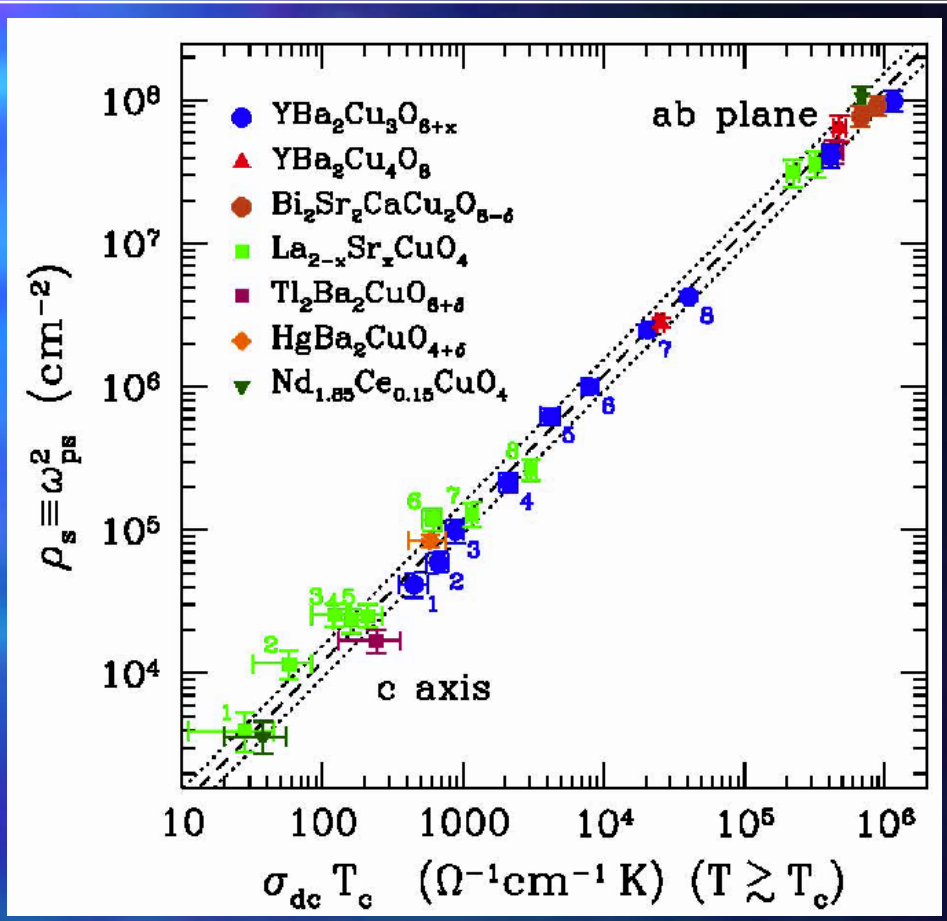
Scaling laws express a systematic and universal simplicity among complex systems in nature. For example, such laws are of enormous significance in biology. Scaling relations are also important in the physical sciences. The seminal 1986 discovery of high transition-temperature (high-Tc) superconductivity in cuprate materials has sparked an intensive investigation of these and related complex oxides, yet the mechanism for superconductivity is still not agreed upon. In addition, no universal scaling law involving such fundamental properties as T_c and the superfluid density ρ_s, a quantity indicative of the number of charge carriers in the superconducting state, has been discovered. Here we demonstrate that the scaling relation $\rho_s \propto \sigma_{dc} \times Tc$, where the conductivity σ_{dc} characterizes the unidirectional, constant flow of electric charge carriers just above Tc, universally holds for a wide variety of materials and doping levels. This surprising unifying observation is likely to have important consequences for theories of high-Tc superconductivity
/to appear in Nature/.

Work carried out in collaboration with C. C. Homes, S. V. Dordevic, M. Strongin, D. A. Bonn, Ruixing Liang, W. N. Hardy, Seiki Koymia, Yoichi Ando, G. Yu, X. Zhao, M. Greven, and T. Timusk.



The log-log plot of the superfluid density ρ_s vs $\sigma_{dc} \times T_c$ for both the *a-b* planes and the *c* axis for a variety of cuprates. Within error, all of the data fall on the same universal (dashed) line with slope of unity.

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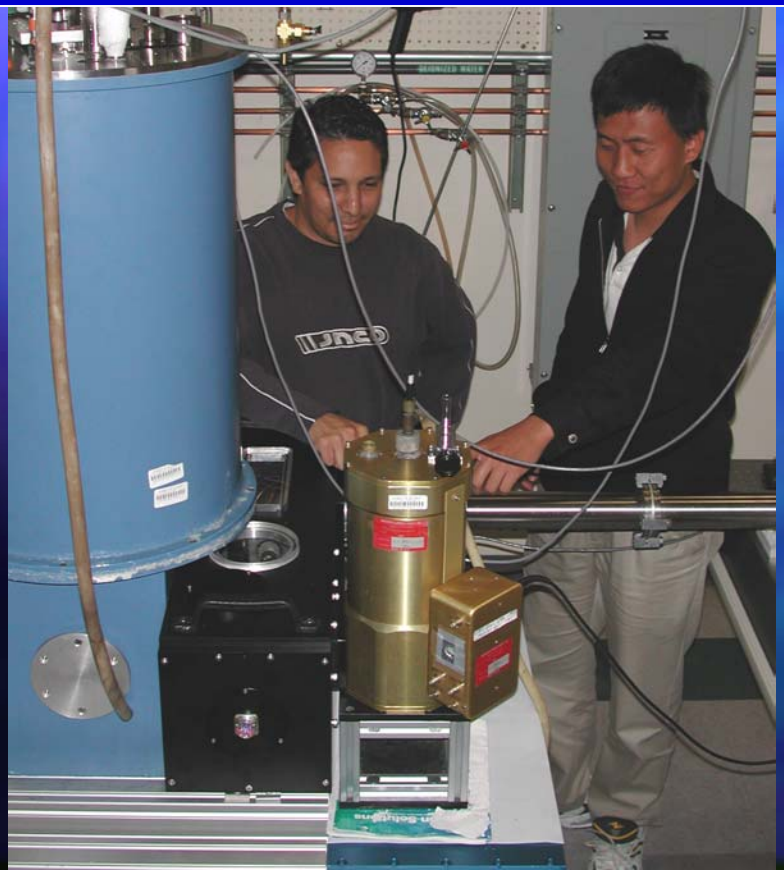
Educational and outreach activities. Funding from this NSF awards has facilitated training of the following graduate students: W.J. Padilla, K.S. Burch, Z.Q.Li, as well as of several undergraduates: David Shrekenhamer, Naim Zarif, Miguel Villalobos. Starting from the Summer of 2004 D.N. Basov also serves as the PI on the NSF-funded REU program at the UCSD physics department.

Dr. W.J. Padilla is training a graduate student Z.Q. Li to align a complex magneto-optics system that he has developed as a part of his Ph.D thesis project in the Basov lab.



Undergraduate students Naim Zarif and David Shrekenhamer make a team presentation on their research in the Basov lab @ UCSD during the Summer 2004.

Dr. William J. Padilla first became involved in research at the UCSD physics department in 1997 as a part of McNair scholars program. The objective of the program is to provide low-income, first-generation college students, and students from groups underrepresented in graduate education, with effective preparation for doctoral study. In 1999 he became a graduate student in the Basov laboratory at UCSD. His thesis work focused on the design of the state-of-the-art magneto-optics system for research in novel electronic and magnetic material. Apart from several publications on high-Tc superconductors Willie discovered artificial magnetic response in THz frequencies in composite structures (Science 303, 1494 (2004). Willie has successfully defended his PhD thesis in the Spring 2004. These accomplishments have resulted in a prestigious Director Fellowship at Los Alamos National Laboratory where he will work on THz photonics starting from August 2004.